APPENDIX 10G

Geologic and Foundation Design Criteria

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10G1 Introduction

This appendix includes the results of past documentation regarding subsurface investigation, and geotechnical assessment for the project to support the Application for Certification (AFC).

This appendix contains a description of the site conditions, and preliminary foundation-related subsurface conditions. Soil related hazards addressed include soil liquefaction, hydrocompaction (or collapsible soils), and expansive soils. Preliminary foundation and earthwork considerations are based on general published information available for the project area including recent geotechnical investigations for the adjacent MUNI Metro East property, and established geotechnical engineering practices. During the preparation of the Design Build Specification, a detailed geotechnical investigation will be conducted to address the subsurface soil conditions in order to develop site-specific and detailed design conditions.

Information contained in this appendix reflects the codes, standards, criteria and practices generally used in the design and construction of site and foundation engineering systems for the facility. More specific project information will be developed during execution of the project to support detailed design, engineering, material procurement, and construction specifications.

10G2 Site Conditions

The site is located near the intersection of 25th Street and Michigan Street. The site topography is relatively flat. Elevations range from 13 to about 15 feet above sea level. The site currently drains towards the bay. The area is generally flat terrain with no permanent structures.

10G3 Site Subsurface Conditions

10.G3.1 Stratigraphy

Generalized stratigraphy is discussed in Section 8.15, Geologic Hazards and Resources. Borings will be performed at the project site to verify the soil consistency and characteristics.

10G3.2 Seismicity/Ground Shaking

The project site is subject to the probability of seismic activities. No known faults traverse through the local soils in or near the site. The San Francisco Bay occupies a wide linear northwest trending structural depression within the Coast Range Geomorphic Province of northern California. The depression, called the San Francisco Bay – Santa Clara Valley

(SFB-SCV) depression, is bounded by the Santa Cruz Mountains to the southwest and the East Bay Hills and Diablo Range to the northeast. The Coastal Range Province consists of sedimentary, metamorphic, volcanic, and igneous rocks predominately ranging in age from the Jurassic/Cretaceous to recent.

Within the San Francisco Bay are located two major fault systems in a historically active tectonic setting—the San Andreas Fault in the west and the Hayward fault in the east. The project site is located approximately 3 miles east of the San Andrea Fault and about 14 miles west of the Hayward Fault.

SFERP is located within the San Francisco Marin Structural Block, bounded on the east by the Hayward fault and on the west by the San Andreas Fault. During the last two million years, the San Francisco Block has tilted with its eastern portion subsiding to form the elongate depression now occupied by the San Francisco Bay. During the same period, the Santa Cruz Mountains, Diablo Range, and Berkeley Hills have been uplifted.

The bedrock of the San Francisco Block consists of Jurassic-Cretaceous rock, belonging to the Franciscan Assemblage and Great Valley sequence. These rocks include graywacke sandstone, conglomerate, chert, serpentinite, cataclasite, and altered volcanics of the Franciscan Assemblage and sandstone and shale of the Great Valley Sequence.

Previous studies and test borings performed at the adjacent MUNI Metro East and Operation Center site indicate the presence of man-made fill and Young Bay Mud underlain by Bay sand and Old Bay Mud.

The project site is susceptible to ground shaking during major earthquakes from the San Andreas or Hayward Faults. The seismic risk to structures depends upon the distance to the epicenter, the characteristics of the earthquake, the geologic, groundwater, and the soil conditions underlying the structures. The site is located in Seismic Zone 4.

10G3.3 Ground Rupture

Ruptures along the surface trace of a fault tend to occur along lines of previous faulting. There is no evidence of potentially active fault trace at the nearby site; and thus the primary hazard of surface rupture at the project site is expected to be negligible. However, a ground rupture study at the project site will be undertaken as part of the site geotechnical investigations in support of the engineering design to verify this assumption.

10G3.4 Groundwater

Groundwater occurs at approximately 5 to 10 feet below ground surface. The groundwater table has to be determined and verified at the project site. The assessment will be undertaken as part of the geotechnical investigation described in the introduction.

10G4 Assessment of Soil-Related Hazards

10G4.1 Liquefaction

Soil liquefaction is a process by which loose, saturated, granular deposits lose a significant portion of their shear strength due to pore water pressure buildup resulting from cyclic loading, such as that caused by an earthquake. Soil liquefaction can lead to foundation bearing failures and excessive settlements when:

- The design ground acceleration is high
- The water level is relatively shallow
- Low SPT blow counts are measured in granular deposits (suggesting low soil density)

Previous investigations indicated primarily fill and Bay Mud overlying bedrock, with fill being relatively thick in areas but containing proportions of rubble and debris.

10G4.2 Expansive Soils

Soil expansion is a phenomenon by which clayey soils expand in volume as a result of an increase in moisture content, and shrink in volume upon drying. Expansive soils are usually identified with index tests, such as percentage of clay particles and liquid limit. It is generally accepted that soils with liquid limits larger than about 50 percent, i.e., soils that classify as high plasticity clays (CH) or high plasticity silts (MH), may be susceptible to volume change when subjected to moisture variations.

Previous data indicates that fill and Bay Mud overburden soils will exhibit no expansive properties.

10G4.3 Collapsible Soils

Soil collapse (hydrocompaction) is a phenomenon that results in relatively rapid settlement of soil deposits due to addition of water. This generally occurs in soils having a loose particle structure cemented together with soluble minerals or with small quantities of clay. Water infiltration into such soils can break down the interparticle cementation, resulting in collapse of the soil structure. Collapsible soils are usually identified with index tests, such as dry density and liquid limit, and consolidation tests where soil collapse potential is measured after inundation under load.

Based on the available data, the potential for soil collapse at the site is expected to be remote. This will be verified by testing of the soil samples retrieved from the detailed geotechnical investigation described in the introduction.

10G5 Preliminary Foundation Considerations

10G5.1 General Foundation Design Criteria

For satisfactory performance, the foundation of any structure must satisfy two independent design criteria. First, it must have an acceptable factor of safety against bearing failure in the foundation soils under maximum design load. Second, settlements during the life of the structure must not be of a magnitude that will cause structural damage, endanger piping connections or impair the operational efficiency of the facility. Selection of the foundation type to satisfy these criteria depends on the nature and magnitude of dead and live loads, the base area of the structure and the settlement tolerances. Where more than one foundation type satisfies these criteria, then cost, scheduling, material availability and local practice will probably influence or determine the final selection of the type of foundation.

An evaluation of the information collected for the AFC indicates that no adverse foundation-related subsurface and ground water conditions would be encountered that would preclude the construction and operation of the proposed structures. The site can be considered suitable for development of the proposed structures contingent upon completion of a detailed geotechnical investigation to support of the engineering design, and using the information to address the preliminary foundation and earthwork considerations discussed in this appendix.

10G5.2 Shallow Foundations

Completion of the geotechnical investigation will determine whether proposed light structures can be supported directly on the fill. Shallow foundation construction will require the earthwork measures discussed in Subsection 10G6, Preliminary Earthwork Considerations.

The decision on whether or not to employ shallow-bearing foundations to support the lighter plant components would also be based on the uniformity, strength, compressibility, and thickness of the fill and Bay Mud overlying the bedrock. If some very slight structures might be placed on shallow foundations, allowable bearing pressures will include a factor of safety against bearing capacity failure of at least 3.0. Tolerable total settlements are expected to be limited to about 1 inch and differential settlement between adjacent structures generally less than 0.5 inch. Aboveground steel water tanks can tolerate several times those magnitudes.

Footings for small/light structures are sized according to allowable bearing capacity and certain construction standards. On sandy soils, a degree of confinement is required to develop bearing capacity. Thus, minimum widths of about 2 feet for wall footings and 3 feet for isolated column footings are generally specified even through the full allowable bearing capacity may not be reached under very light loading.

10G5.3 Deep Foundations

Both the variable thickness and low consistency (low strength and high compressibility) of fill and the Bay Mud deposits suggest that a deep foundation consisting of piles or caissons may be required to support virtually all heavy components of the SFERP.

A foundation report will be issued which addresses foundation selection and installation particular to the soil conditions under the major components. The character of the fill material, and range of thickness from a few feet up to 26 feet, also dictate that the method of installation and pile type selection for the deep foundation account for variable lengths and obstructions which present hard driving conditions. The overburden soils will probably contribute very little reliable side-support or skin friction component to a pile foundation at this site. The SPT values obtained in the fill are not reliable as a measure of soil consistency if the fill contains construction debris and random common fill dumped in an uncontrolled fashion.

A necessary component of selecting and installing deep foundations is the design and implementation of a pile test program particular to the pile type, required loading, and bearing material. Since test borings may not define the full range of soil conditions at a site, nor lab testing measure strength of all soil involved, test piles are driven/installed at several locations on site prior to production driving. Through use of full-scale load tests or PDA (pile driving analyzer) testing, the estimated load capacity of a singular pile can be verified or adjusted as necessary, often measuring both end bearing and friction components.

Under most conditions, the factor of safety against bearing capacity failure must be at least 2.0 for deep foundations. When high lateral and uplift loads are important (the stack as an example), the testing program is also designed to measure this performance as well. Load-deflection curves are used for lateral capacity verification, and uplift or pull-out tests measure skin friction performance alone, usually designed for a factor of safety of at least 3.0. Individual pile capacities are adjusted for group effects based on pile center-to-center spacings and soil strength moduli.

Liquefaction potential can affect foundation performance even for deep foundations that extend through the liquefiable soils to firm strata below. Liquefaction is a temporary quick condition, which reduces the strength of submerged granular soils to virtually zero. Under this condition, the side or skin friction support on piles can be temporarily lost, and the pile foundation must be designed to derive added load capacity through extra embedment or tip dimension.

10G5.4 Corrosion Potential and Ground Aggressiveness

Corrosivity tests will be conducted to determine whether the site soils to be non-corrosive or corrosive for buried steel based on the chloride content and pH values.

10G6 Preliminary Earthwork Considerations

10G6.1 Site Preparation and Grading

Site grading may include (1) removal of existing deleterious materials and (2) fill to bring the site to a final grade. The site fill work should be performed as detailed below. All soil surfaces to receive fill should be proof rolled with a heavy vibratory roller or a fully loaded dump truck to detect soft areas.

10G6.2 Temporary Excavations

It is anticipated that confined temporary excavations at the site will be required during construction. All excavations should be sloped in accordance with OSHA requirements. Sheet piling could also be used to support any excavation. The need for internal supports in the excavation will be determined based on the final depth of the excavation. Any excavation below the water table should be dewatered using well points installed prior to the start of excavation.

10G6.3 Backfill Requirements

All fill material must be free of organic matter, debris or clay balls, with a maximum size not exceeding 2 inches. Structural fill must also be well graded and granular. Granular material with similar specifications can be used for pipe bedding, except that the maximum size should not exceed 0.5 inch.

Structural fill should be compacted to at least 95 percent of the maximum dry density as determined by ASTM D 1557 when used for raising the grade throughout the site, below footings or mats, or for rough grading. Fill placed behind retaining structures may be compacted to 90 percent of the maximum dry density as determined by ASTM D 1557. Initially, structural fill should be placed in lifts not exceeding 8 inches loose thickness. Thicker lifts may be used pursuant to approval based on results of field compaction performance. The moisture content of all compacted fill should fall within 3 percentage points of the optimum moisture content measured by ASTM D 1557, except compact the top 12 inches of subgrade to 95 percent of ASTM D 1557 maximum density.

Pipe bedding can be compacted in 12-inch lifts to 90 percent of the maximum dry density as determined by ASTM D 1557. Common fill to be placed in remote and/or unsurfaced areas may be compacted in 12-inch lifts to 85 percent of the maximum dry density as determined by ASTM D 1557.

10G7 Inspection and Monitoring

A California-registered Geotechnical Engineer or Engineering Geologist will monitor geotechnical aspects of foundation construction and/or installation, and fill placement. At a minimum the Geotechnical Engineer/Engineering Geologist will monitor the following activities:

- All surfaces to receive fill should be inspected prior to fill placement to verify that no pockets of loose/soft or otherwise unsuitable material were left in place and that the subgrade is suitable for structural fill placement.
- All fill placement operations should be monitored by an independent testing agency. Field compaction control testing should be performed regularly and in accordance with the applicable specification to be issued by the Geotechnical Engineer.
- The Geotechnical Engineer must witness all pile load testing and initial stages of production pile installation.
- Settlement monitoring of significant foundations and equipment is recommended on at least a quarterly basis during construction and the first year of operation, and then semi-annually for the next 2 years.

10G8 Site Design Criteria

10G8.1 General

The project will be located in the City and County of San Francisco, California. The approximate 4-acre site is relatively flat, with no permanent structures. The site would be accessible from 25th Street or Cesar Chavez Street.

10G8.2 Datum

The site grade varies between 13 to 15 feet, mean sea level, based on the elevation of the adjacent MUNI Metro East site. Final site grade elevation will be determined.

10G9 Foundation Design Criteria

10G9.1 General

Reinforced concrete structures (spread footings, mats and deep foundations) will be designed consistent with Appendix 10B.

Allowable soil bearing pressures for foundation design will be in accordance with this appendix.

10G9.2 Groundwater Pressures

Hydrostatic pressures due to groundwater or temporary water loads will be considered.

10G9.3 Factors of Safety

The factor of safety for structures, tanks and equipment supports with respect to overturning, sliding, and uplift due to wind and buoyancy will be as defined in Appendix 10B, Structural Engineering Design Criteria.

10G9.4 Load Factors and Load Combinations

For reinforced concrete structures and equipment supports, using the strength method, the load factors and load combinations will be in accordance with Appendix 10B, Structural Engineering Design Criteria.

10G10 References

California Building Code. 2001.